NOAA National Geophysical Data Center

External Users Manual
POES/MetOp SEM-2 Processing

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AUTHORS:

Janet Green (NOAA National Geophysical Data Center)

DOCUMENT HISTORY
DOCUMENT REVISION LOG

The Document Revision Log identifies the series of revisions to this document since the baseline release. Please refer to the above page for version number information.

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LIST OF CHANGES

Significant alterations made to this document are annotated in the List of Changes table.

DOCUMENT TITLE: External Users Manual POES/MetOp SEM-2 Processing					
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Version Number	**Date**	**Changed By**	**Page**	**Section**	**Description of Change(s)**
					“

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1. PRODUCT

1.1. Product Overview

1.1.1. Product Team

Project Manager/Instrument Scientist: Janet Green
Developer: Anu Sandraval, Janet Green, Ken Tanaka, Ernie Joynt, Tom Carey

1.1.2. Product Description

The product described here is the raw and processed data from the Space Environment Monitor-2 instrument suite on the NOAA POES and EUMETSAT MetOp polar orbiting sun synchronous satellites. Each satellite currently carries duplicate SEM-2 sensors that measure the space particle radiation that creates the aurora and forms the Earth's radiation belts. The raw and processed data is derived from the SEM-2 level 1B sensor data. The processing transforms the data into environmental information needed for monitoring the space radiation impacts on such things as atmospheric chemistry and satellite systems. The processing changes the raw sensor bits to physical quantities with error bars and adds additional information such as the local magnetic field components that are needed for interpreting the spatial and temporal variation of the data. The processing works on the near real time level-1b data files retrieved from the NOAA Data Distribution System (DDS) and makes the level-2 data immediately available to outside users. The near real time data are telemetered to the ground approximately once per 100 minute satellite orbit.

1.2. Product History

A form of the POES/MetOp level-2 processing was originally developed and run by the NOAA Space Weather Prediction Center [*Greer and Evans*, 2000]. The new processing system and data products described here is intended to replace the legacy SWPC system due to a variety of reasons such as maintenance challenges and improved data accuracy.

1.3. Product Access

The SEM-2 data product is separated into 2 netcdf files: raw and processed. They can be accessed at http://satdat.ngdc.noaa.gov/sem/poes/data/processed/ngdc/uncorrected and http://satdat.ngdc.noaa.gov/sem/poes/data/raw/ngdc/. The full directory structure and file naming conventions are shown in Table 1-1 and Table 1-2. These tables contain the directory structure for accessing all the SEM-2 datasets including the legacy SWPC generated data and also placeholders for datasets not yet available but anticipated in the future.

Table 1-1: Directory structure for the raw SEM-2 data

Main folder	Secondary structure	Filename	description	Data type
/raw	/swpc/year/satid*	poes_id_YYYYMMDD.rax	Counts from SWPC	Binary
	/ngdc/year/satid*	poes_id_YYYYMMDD_raw.nc	Counts from new NGDC processing	Netcdf

Table 1-2: Directory structure for the processed SEM-2 data

Main folder	Secondary structure	Tertiary structure	Quaternary structure	Filename	Description	Data type
/processed	/swpc	/corrected	/full/year/satid *	poes_id_YYYYMMDD.cdf **	Derived from SWPC uncorrected	cdf
		/uncorrected	/full/year/satid *	poes_id_YYYYMMDD.bin **	Fluxes from SWPC	binary
			/avg/year/satid *	poes_id_YYYYMMDD.cdf poes_id_YYYYMMDD.txt **	16 s averaged fluxes from SWPC	Cdf,ASCII
	/ngdc	/corrected	/full/year/satid *	Not done yet		
			/avg/year/satid *	Not done yet		
		/uncorrected	/full/year/satid *	poes_id_YYYYMMDD_proc.nc **	Fluxes from new ngdc processing	Netcdf
			/avg/year/satid *	Not done yet		

*satid stands for metop01,metop02,metop03,noaa15,noaa16,noaa17,noaa18 or noaa19
**id stands for 01,02,03,15,16,17,18,19

Both the updating near real time data files and the retrospective data files are available in the same directory location. The near real time data is added to the current day file as it becomes available. Questions about accessing the data should be directed to Daniel.Wilkinson@noaa.gov and Janet.Green@noaa.gov at the NOAA National Geophysical Data Center.

The raw data files contain sensor data in units of counts with no additional improvements or added parameters such as the magnetic field model information. These data are most valuable for evaluating the sensor performance. The processed data files contain the sensor data transformed into physical units with error bars and backgrounds removed. This data should be used for scientific analysis. The size of the raw and processed data files varies but is ~20 Mb and 50 Mb respectively. The contents of each data file are described in Table A-1 in Appendix A. The first column of this table gives the variable name, the second column specifies which file the variable is in (‘a’ for all, ‘r’ for raw, and ‘p’ for processed), the third gives the type, the fourth gives the size, the fifth gives the minimum value, the sixth gives the max value and last is the units.

2. ALGORITHM

2.1. Algorithm Overview

At a top level, the SEM-2 data processing system encodes different algorithm sets that apply to each detector in the SEM-2 instrument suite plus additional algorithms for the supplemental information added to put the data into the context of Earth's magnetosphere. Each set is described in detail by its own algorithm theoretical basis document. Here we provide only a broad overview of those algorithms.

2.2. Input Satellite Data

2.2.1. Satellite Instrument Overview

The processed data is derived from the POES/MetOp SEM-2 instrument suite measurements. The suite consists of 2 distinct instruments: TED and MEPED. The purpose of the TED instrument is to sample the lowest energy electron and proton populations that are responsible for producing the aurora, modifying the ionosphere such that GPS capabilities are degraded, and contributing to satellite surface charging effects. The purpose of the MEPED instrument is to measure the higher energy protons and electrons that form the radiation belts responsible for satellite malfunctions and health hazards for astronauts and flight crew.

2.2.1.1 TED Instrument

The primary output of the TED instrument is proton and electron energy flux in 2 look directions integrated over 2 broad energy bands. TED relies on a set of 8 electrostatic analyzers (ESA's) to make these measurements. The instrument performs 5 main functions: separates the species (proton or electron), limits the direction, selects the energy range, amplifies the signal, and assesses backgrounds. For a very detailed explanation of the instrument, its limitations, and accuracy please refer to the TED data processing ATBD.

2.1.2 MEPED Instrument

The MEPED instrument measures the flux of higher energy protons and electrons. Although it is considered a single instrument it really consists of 2 distinct parts: a set of telescopes for measuring medium energy proton and electron flux and a set of dome detectors for measuring the very highest energy proton flux. These are called out as separate systems because their structure and design is fundamentally different and thus require different processing strategies. Separate ATBD's are available that describe the processing of each system. There are total of 4 telescopes and 4 domes. Two of the telescopes measure proton flux with one telescope pointed nearly along the zenith and the other pointed at 90 degrees from the zenith. The remaining 2 telescopes measure electron flux again with one pointed nearly along the zenith and the other pointed at 90 degrees. The domes are entirely devoted to measuring protons. For a more detailed description see the MEPED telescope data processing ATBD and the MEPED omni data processing ATBD.

2.2.2. Satellite Data Preprocessing Overview

The POES/MetOp data are typically telemetered to the ground once per satellite orbit at a number of ground stations. The data are received by NSOF where the SEM-2 data are separated and packaged into level1B files. These files contain all the TED and MEPED data along with additional information such as the satellite orbit, telemetry quality and housekeeping values (temperatures and voltages for instrument health monitoring). Once processed and packaged the data are made available via the Data Distribution System (DDS) that requires approval for access by real-time data users. The NGDC processing system checks for new data from the DDS every 2 minutes.

2.2.3. Input Satellite Data Description

The main input to the processing is the level 1B files from the DDS system. The structure of the files is described in Appendix B. One file is provided per satellite per orbit giving approximately 14 input files per day.

2.3. Input Ancillary Data

Ancillary data are defined as data that are not generated on-orbit by SEM-2 or the spacecraft. The SEM-2 data processing requires 2 types of ancillary data: calibration data and magnetic field data.

2.3.1 Calibration Data

Separate calibration data are used for the TED and MEPED instrument processing.

The TED instrument requires 3 calibration files as input to the processing. These are static ascii files that are maintained at NGDC and are read in every time a new input data file is processed. The first file, ted_cal_coefficients.txt, contains the values needed to change the 8 energy flux measurements from energy flux counts to energy flux units (milliWatts/m^2). The second file, spectrum_coefficients.txt, contains the values needed to change the counts measured in the 16 smaller energy bands to differential particle flux (#/cm2-s-str-eV). The third file, ted_weights.txt, contains values needed by the ground processing algorithm to change the background counts that have no onboard processing to the same units as the energy flux counts. More details about these files and how they are derived are given in the TED data processing ATBD.

The MEPED instrument requires a single calibration file as input to the processing. This is also a static ascii file maintained at NGDC that is read in every time a new input data file is processed. The calibration data referred to here are a table of values by which the raw sensor data is multiplied to translate the number of particles counted in each energy channel to physical flux units. For more details about the contents and derivation of the calibration data please refer to the MEPED data processing ATBD.

2.3.2 Magnetic Field Data

The magnetic field ancillary data is contained in ascii tables that provide the coefficients for expanding Earth's internal field as spherical harmonics. These tables are used to predict the magnetic field at the satellite location because there is no magnetometer onboard to provide that measurement. The magnetic field is critical for determining how the particle measurements relate to the field direction and which particles are expected to continue along the field lines to the atmosphere. Due to some legacy code being used in the processing, the IGRF coefficients are duplicated in several files. The file called igrf11coefficients.txt contains all the igrf data from 1900 to 2010 at five year intervals. This file must be updated at regular 5 year intervals. Additionally, the igrf coefficients are also contained in individual 5 year files (dgrf00.dat, dgrf05.dat, igrf05.dat, and igrf00.dat). These will need to be updated every 5 years as well and supplemented to reprocess any older data prior to 2000. The IGRF coefficients can be obtained from http://www.ngdc.noaa.gov/IAGA/vmod/igrf.html.

3. PERFORMANCE

3.1. Product Testing

There are two objectives to testing the performance of the SEM-2 data processing algorithms. The first objective is to ensure that there are no flaws in the method or implementation of the algorithms. This objective is met by simply comparing the output to that from the legacy processing. The second objective is to provide users with an assessment of the accuracy of the output data. The results of these tests are described in section 3.2.

3.1.1. Test Data Description

The legacy files used to compare to the new processing are the full resolution daily binary archive fails produced by NOAA SWPC up until Jan 2013 and archived at NGDC. The contents of the files are described by Greer and Evans [2000].

3.1.2. Unit Test Plans

NA

3.2. Product Accuracy

3.2.1. Test Results

To ensure that there are no fundamental flaws in the new processing we compare all values contained in the legacy archive files to the newly processed files for the same time periods. Both files are produced from the same L1B input files. In some cases, the outputs from two processes should be exactly the same because the algorithms used by both are identical. For example, both systems produce TED and MEPED counts from the same simple look-up table translation. In these cases, our comparisons show no difference demonstrating no issues with the new implementation. In other cases, the outputs may be different because of small difference in the methods. The details of these differences and comparisons are discussed in the MEPED and TED data processing ATBDs. The largest differences in the 2 processing outputs are seen in the magnetic field parameters. The magnetic field parameters from both systems are generated using the same IGRF field model however, the implementation is slightly different. The legacy software relied on static files of the IGRF field model as a function of latitude and longitude that were updated once per year. The new processing calls the IGRF field model for every 2 second data record and provides a more up-to-date representation. Even though differences in the magnetic field parameters are apparent they are largest near the equator where no particles are typically observed thus, they should not affect the use and interpretation of the data.

3.2.2. Product Accuracy

Error bars are included along with all physical parameters in order to demonstrate the accuracy of the product. The error bars include errors from the Poisson counting statistics and any known measured errors in the calibration factors. However, other known errors are not currently addressed due to challenges quantify the effects. Users should be wary of these when interpreting the data. For example, the MEPED instrument suffers from degradation, cross species contamination and satellite intercalibration differences. These are discussed in more detail in the MEPED omni and telescope ATBD’s. The TED instrument also suffers from a different form of degradation, unknown calibration uncertainties and satellite intercalibration differences. These are discussed in more detail in the TED ATBD’s.

3.3. Product Quality Output

It is anticipated that users will rely on the error calculations for product quality rather than quality flags.

3.4. External Product Tools

None available at this time.

4. PRODUCT STATUS

4.1. Operations Documentation

Operations are described by the following documents:

TED data processing ATBD:
This document provides a description of the algorithms and procedures used to transform the output from the Total Energy Detector (TED) into higher level data products including local energy flux, energy flux at the atmosphere, and differential particle flux. Error propagation, validation and examples of the algorithm are discussed. The logical flow of the algorithm is outlined.

MEPED data processing ATBD:

This document provides a description of the algorithms and procedures used to transform the output from the Medium Energy Proton and Electron Detector (MEPED) telescopes on the POES/MetOp satellites into higher level data products such as differential particle flux. Error propagation, validation and examples of the algorithm are discussed. The logical flow of the algorithm is outlined.

Internal Users Manual:
This document describes the details of the entire processing system including a brief overview of the algorithms, the production scenario, the product access, and diagnostics.

4.2. Maintenance History

NA

Appendix A: Contents of raw and processed data files

Table A-1: Contents of SEM-2 data files

Variable name	file	value	size	min	max	units
year	a	int	4	1950	2050	year
day	a	int	3	0	366	day
msec	a	int	8	0	86400000	millisec
satID	a	int	2	0		ID
minor_frame	r	int	3	0	320	frame
major_frame	r	int	3	0	7	frame
sat_direction	a	int	1	0	1	
alt	a	float	7.3	800	1000	km
lat	a	float	7.3	-90	90	degrees
lon	a	float	7.3	0	360	degrees
mep_pro_tel0_cps_p1	r	float	9.1	0	1998848	#/s
mep_pro_tel0_cps_p2	r	float	9.1	0	1998848	#/s
mep_pro_tel0_cps_p3	r	float	9.1	0	1998848	#/s
mep_pro_tel0_cps_p4	r	float	9.1	0	1998848	#/s
mep_pro_tel0_cps_p5	r	float	9.1	0	1998848	#/s
mep_pro_tel0_cps_p6	r	float	9.1	0	1998848	#/s
mep_pro_tel90_cps_p1	r	float	9.1	0	1998848	#/s
mep_pro_tel90_cps_p2	r	float	9.1	0	1998848	#/s
mep_pro_tel90_cps_p3	r	float	9.1	0	1998848	#/s
mep_pro_tel90_cps_p4	r	float	9.1	0	1998848	#/s
mep_pro_tel90_cps_p5	r	float	9.1	0	1998848	#/s
mep_pro_tel90_cps_p6	r	float	9.1	0	1998848	#/s
mep_pro_tel0_flux_p1	p	float	14.5	0		#/cm2-s-str-keV

mep_pro_tel0_flux_p2	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel0_flux_p3	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel0_flux_p4	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel0_flux_p5	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel0_flux_p6	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel0_flux_p1_err	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel0_flux_p2_err	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel0_flux_p3_err	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel0_flux_p4_err	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel0_flux_p5_err	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel0_flux_p6_err	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel90_flux_p1	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel90_flux_p2	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel90_flux_p3	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel90_flux_p4	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel90_flux_p5	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel90_flux_p6	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel90_flux_p1_err	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel90_flux_p2_err	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel90_flux_p3_err	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel90_flux_p4_err	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel90_flux_p5_err	p	float	14.5	0		#/cm2-s-str-keV
mep_pro_tel90_flux_p6_err	p	float	14.5	0		#/cm2-s-str-keV
mep_ele_tel0_cps_e1	r	float	9.1	0	1998848	#/s
mep_ele_tel0_cps_e2	r	float	9.1	0	1998848	#/s
mep_ele_tel0_cps_e3	r	float	9.1	0	1998848	#/s
mep_ele_tel90_cps_e1	r	float	9.1	0	1998848	#/s
mep_ele_tel90_cps_e2	r	float	9.1	0	1998848	#/s
mep_ele_tel90_cps_e3	r	float	9.1	0	1998848	#/s
mep_ele_tel0_flux_e1	p	float	14.5	0		#/cm2-s-str
mep_ele_tel0_flux_e2	p	float	14.5	0		#/cm2-s-str
mep_ele_tel0_flux_e3	p	float	14.5	0		#/cm2-s-str
mep_ele_tel0_flux_e4	p	float	14.5	0		#/cm2-s-str
mep_ele_tel0_flux_e1_err	p	float	14.5	0		#/cm2-s-str
mep_ele_tel0_flux_e2_err	p	float	14.5	0		#/cm2-s-str
mep_ele_tel0_flux_e3_err	p	float	14.5	0		#/cm2-s-str
mep_ele_tel0_flux_e4_err	p	float	14.5	0		#/cm2-s-str
mep_ele_tel90_flux_e1	p	float	14.5	0		#/cm2-s-str
mep_ele_tel90_flux_e2	p	float	14.5	0		#/cm2-s-str
mep_ele_tel90_flux_e3	p	float	14.5	0		#/cm2-s-str
mep_ele_tel90_flux_e4	p	float	14.5	0		#/cm2-s-str
mep_ele_tel90_flux_e1_err	p	float	14.5	0		#/cm2-s-str
mep_ele_tel90_flux_e2_err	p	float	14.5	0		#/cm2-s-str
mep_ele_tel90_flux_e3_err	p	float	14.5	0		#/cm2-s-str

mep_ele_tel90_flux_e4_err	p	float	14.5	0		#/cm2-s-str
mep_omni_cps_p6	r	float	10.2	0	1998848	#/s
mep_omni_cps_p7	r	float	10.2	0	1998848	#/s
mep_omni_cps_p8	r	float	10.2	0	1998848	#/s
mep_omni_cps_p9	r	float	10.2	0	1998848	#/s
mep_omni_flux_p1	p	float	11.5	0		#/cm2-s-str
mep_omni_flux_p2	p	float	11.5	0		#/cm2-s-str
mep_omni_flux_p3	p	float	11.5	0		#/cm2-s-str
mep_omni_flux_flag_fit	p	int	2.0	-1	2	flag
mep_omni_flux_flag_iter_lim	p	int	2.0	0	1	true/false
mep_omni_gamma_p1	p	float	9.1			
mep_omni_gamma_p2	p	float	9.1			
mep_omni_gamma_p3	p	float	9.1			
ted_ele_tel0_cps_4	r	float	9.1	0	1998848	counts
ted_ele_tel0_cps_8	r	float	9.1	0	1998848	counts
ted_ele_tel0_cps_11	r	float	9.1	0	1998848	counts
ted_ele_tel0_cps_14	r	float	9.1	0	1998848	counts
ted_ele_tel30_cps_4	r	float	9.1	0	1998848	counts
ted_ele_tel30_cps_8	r	float	9.1	0	1998848	counts
ted_ele_tel30_cps_11	r	float	9.1	0	1998848	counts
ted_ele_tel30_cps_14	r	float	9.1	0	1998848	counts
ted_pro_tel0_cps_4	r	float	9.1	0	1998848	counts
ted_pro_tel0_cps_8	r	float	9.1	0	1998848	counts
ted_pro_tel0_cps_11	r	float	9.1	0	1998848	counts
ted_pro_tel0_cps_14	r	float	9.1	0	1998848	counts
ted_pro_tel30_cps_4	r	float	9.1	0	1998848	counts
ted_pro_tel30_cps_8	r	float	9.1	0	1998848	counts
ted_pro_tel30_cps_11	r	float	9.1	0	1998848	counts
ted_pro_tel30_cps_14	r	float	9.1	0	1998848	counts
ted_ele_tel0_flux_4	p	float	13.1	0	4E+09	[#/cm2-s-str-eV]
ted_ele_tel0_flux_8	p	float	13.1	0	4E+09	[#/cm2-s-str-eV]
ted_ele_tel0_flux_11	p	float	13.1	0	4E+09	[#/cm2-s-str-eV]
ted_ele_tel0_flux_14	p	float	13.1	0	4E+09	[#/cm2-s-str-eV]
ted_ele_tel30_flux_4	p	float	13.1	0	4E+09	[#/cm2-s-str-eV]
ted_ele_tel30_flux_8	p	float	13.1	0	4E+09	[#/cm2-s-str-eV]
ted_ele_tel30_flux_11	p	float	13.1	0	4E+09	[#/cm2-s-str-eV]
ted_ele_tel30_flux_14	p	float	13.1	0	4E+09	[#/cm2-s-str-eV]
ted_pro_tel0_flux_4	p	float	13.1	0	4E+09	[#/cm2-s-str-eV]
ted_pro_tel0_flux_8	p	float	13.1	0	4E+09	[#/cm2-s-str-eV]
ted_pro_tel0_flux_11	p	float	13.1	0	4E+09	[#/cm2-s-str-eV]
ted_pro_tel0_flux_14	p	float	13.1	0	4E+09	[#/cm2-s-str-eV]
ted_pro_tel30_flux_4	p	float	13.1	0	4E+09	[#/cm2-s-str-eV]
ted_pro_tel30_flux_8	p	float	13.1	0	4E+09	[#/cm2-s-str-eV]
ted_pro_tel30_flux_11	p	float	13.1	0	4E+09	[#/cm2-s-str-eV]

ted_pro_tel30_flux_14	p	float	13.1	0	4E+09	[#/cm2-s-str-eV]
ted_ele_tel0_low_eflux_cps	r	float	9.1	0	1998848	counts
ted_ele_tel30_low_eflux_cps	r	float	9.1	0	1998848	counts
ted_ele_tel0_hi_eflux_cps	r	float	9.1	0	1998848	counts
ted_ele_tel30_hi_eflux_cps	r	float	9.1	0	1998848	counts
ted_pro_tel0_low_eflux_cps	r	float	9.1	0	1998848	counts
ted_pro_tel30_low_eflux_cps	r	float	9.1	0	1998848	counts
ted_pro_tel0_hi_eflux_cps	r	float	9.1	0	1998848	counts
ted_pro_tel30_hi_eflux_cps	r	float	9.1	0	1998848	counts
ted_ele_tel0_low_eflux	p	float	15.9	-200	200	mW/m2-str
ted_ele_tel30_low_eflux	p	float	15.9	-200	200	mW/m2-str
ted_ele_tel0_hi_eflux	p	float	15.9	-200	200	mW/m2-str
ted_ele_tel30_hi_eflux	p	float	15.9	-200	200	mW/m2-str
ted_pro_tel0_low_eflux	p	float	15.9	-200	200	mW/m2-str
ted_pro_tel30_low_eflux	p	float	15.9	-200	200	mW/m2-str
ted_pro_tel0_hi_eflux	p	float	15.9	-200	200	mW/m2-str
ted_pro_tel30_hi_eflux	p	float	15.9	-200	200	mW/m2-str
ted_ele_tel0_low_eflux_error	p	float	15.9			mW/m2-str
ted_ele_tel30_low_eflux_error	p	float	15.9			mW/m2-str
ted_ele_tel0_hi_eflux_error	p	float	15.9			mW/m2-str
ted_ele_tel30_hi_eflux_error	p	float	15.9			mW/m2-str
ted_pro_tel0_low_eflux_error	p	float	15.9			mW/m2-str
ted_pro_tel30_low_eflux_error	p	float	15.9			mW/m2-str
ted_pro_tel0_hi_eflux_error	p	float	15.9			mW/m2-str
ted_pro_tel30_hi_eflux_error	p	float	15.9			mW/m2-str
ted_ele_eflux_atmo_low	p	float	15.9	-6400	6400	mW/m2
ted_ele_eflux_atmo_hi	p	float	15.9	-6400	6400	mW/m2
ted_ele_eflux_atmo_total	p	float	15.9	-12800	6400	mW/m2
ted_ele_eflux_atmo_low_err	p	float	15.9	-6400	6400	mW/m2
ted_ele_eflux_atmo_hi_err	p	float	15.9	-6400	6400	mW/m2
ted_ele_eflux_atmo_total_err	p	float	15.9	-6400	6400	mW/m2
ted_pro_eflux_atmo_low	p	float	15.9	-6400	6400	mW/m2
ted_pro_eflux_atmo_hi	p	float	15.9	-6400	6400	mW/m2
ted_pro_eflux_atmo_total	p	float	15.9	-12800	12800	mW/m2
ted_pro_eflux_atmo_low_err	p	float	15.9	-6400	6400	mW/m2
ted_pro_eflux_atmo_hi_err	p	float	15.9	-6400	6400	mW/m2
ted_pro_eflux_atmo_total_err	p	float	15.9	-12800	12800	mW/m2
ted_total_eflux_atmo	p	float	16	-25600	25600	mW/m2
ted_total_eflux_atmo_err	p	float	16	-25600	25600	mW/m2
ted_ele_energy_tel0	p	int	2	0	15	energy channel
ted_ele_energy_tel30	p	int	2	0	15	energy channel
ted_pro_energy_tel0	p	int	2	0	15	energy channel
ted_pro_energy_tel30	p	int	2	0	15	energy channel
ted_ele_max_flux_tel0	p	float	13.1	0	4E+09	[#/cm2-s-str-eV]

ted_ele_max_flux_tel30	p	float	13.1	0	4E+09	[#/cm2-s-str-eV]
ted_pro_max_flux_tel0	p	float	13.1	0	4E+09	[#/cm2-s-str-eV
ted_pro_max_flux_tel30	p	float	13.1	0	4E+09	[#/cm2-s-str-eV
ted_ele_eflux_bg_tel0_low	p	float	15.9	0	200	mW/m2-str
ted_ele_eflux_bg_tel30_low	p	float	15.9	0	200	mW/m2-str
ted_ele_eflux_bg_tel0_hi	p	float	15.9	0	200	mW/m2-str
ted_ele_eflux_bg_tel30_hi	p	float	15.9	0	200	mW/m2-str
ted_pro_eflux_bg_tel0_low	p	float	15.9	0	200	mW/m2-str
ted_pro_eflux_bg_tel30_low	p	float	15.9	0	200	mW/m2-str
ted_pro_eflux_bg_tel0_hi	p	float	15.9	0	200	mW/m2-str
ted_pro_eflux_bg_tel30_hi	p	float	15.9	0	200	mW/m2-str
ted_ele_eflux_bg_tel0_low_cps	p	float	9.1	0	1998848	counts
ted_ele_eflux_bg_tel30_low_cps	p	float	9.1	0	1998848	counts
ted_ele_eflux_bg_tel0_hi_cps	p	float	9.1	0	1998848	counts
ted_ele_eflux_bg_tel30_hi_cps	p	float	9.1	0	1998848	counts
ted_pro_eflux_bg_tel0_low_cps	p	float	9.1	0	1998848	counts
ted_pro_eflux_bg_tel30_low_cps	p	float	9.1	0	1998848	counts
ted_pro_eflux_bg_tel0_hi_cps	p	float	9.1	0	1998848	counts
ted_pro_eflux_bg_tel30_hi_cps	p	float	9.1	0	1998848	counts
microA_V	r	float	5.1			V
microB_V	r	float	5.1			V
DPU_V	r	float	5.1			V
MEPED_V	r	float	5.1			V
ted_V	r	float	5.1			V
ted_sweepV	r	float	5.1			V
ted_electron_CEM_V	r	float	5.1			V
ted_proton_CEM_V	r	float	5.1			V
mep_omni_bias_V	r	float	5.1			V
mep_circuit_temp	r	float	5.1			K
mep_proton_tel_temp	r	float	5.1			K
TED_temp	r	float	5.1			K
DPU_temp	r	float	5.1			K
Br_sat	p	float	6.1	-32000	32000	nT
Bt_sat	p	float	6.1	-32000	32000	nT
Bp_sat	p	float	6.1	-32000	32000	nT
Btot_sat	p	float	6.1	-32000	32000	nT
Br_foot	p	float	6.1	-32000	32000	nT
Bt_foot	p	float	6.1	-32000	32000	nT
Bp_foot	p	float	6.1	-32000	32000	nT
Btot_foot	p	float	6.1	-32000	32000	nT
geod_lat_foot	p	float	4.1	-90	90	deg
geod_lon_foot	p	float	4.1	0	360	deg
aacgm_lat_foot	p	float	4.1	-90	90	deg
aacgm_lon_foot	p	float	4.1	0	360	deg

mag_lat_foot	p	float	4.1	-90	90	deg
mag_lon_foot	p	float	4.1	0	360	deg
mag_lat_sat	p	float	4.1	-90	90	deg
mag_lon_sat	p	float	4.1	0	360	deg
Bx_sat	p	float	6.1	-32000	32000	nT
By_sat	p	float	6.1	-32000	32000	nT
Bz_sat	p	float	6.1	-32000	32000	nT
ted_alpha_0_sat	p	float	4.1	0	180	deg
ted_alpha_30_sat	p	float	4.1	0	180	deg
ted_alpha_0_foot	p	float	4.1	0	180	deg
ted_alpha_30_foot	p	float	4.1	0	180	deg
meped_alpha_0_sat	p	float	4.1	0	180	deg
meped_alpha_90_sat	p	float	4.1	0	180	deg
meped_alpha_0_foot	p	float	4.1	0	180	deg
meped_alpha_90_foot	p	float	4.1	0	180	deg
L_IGRF	p	float	4.1	0	20	
MLT	p	float	4.1	0	25	hours
HK_data	r	float	10.2			variable
HK_key	r	int	4			key value
ted_ele_PHD_level	r	int	2.0	0	3	level
ted_pro_PHD_level	r	int	2.0	0	3	level
ted_IFC_on	a	int	1.0	0	1	on/off
mep_IFC_on	a	int	1.0	0	1	on/off
ted_ele_HV_step	r	int	2.0	0	7	step
ted_pro_HV_step	r	int	2.0	0	7	step